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REINFORCEMENT MAGNITUDE AND RESPONDING DURING TREATMENT WITH DIFFERENTIAL REINFORCEMENT

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Basic findings indicate that the amount or magnitude of reinforcement can influence free-operant responding prior to and during extinction. In this study, the relation between reinforcement magnitude and adaptive behavior was evaluated with 3 children as part of treatment with differential reinforcement. In the first experiment, a communicative response was shaped and maintained by the same reinforcer that was found to maintain problem behavior. Two reinforcement magnitudes (20-s or 60-s access to toys or escape from demands) were compared and found to be associated with similar levels of resistance to extinction. The relation between reinforcement magnitude and response maintenance was further evaluated in the second experiment by exposing the communicative response to 20-s or 300-s access to toys or escape. Results for 2 participants suggested that this factor may alter the duration of postreinforcement pauses.

DESCRIPTORS: differential reinforcement, extinction, functional communication training, reinforcement magnitude, resistance, severe behavior disorders

Reinforcement effects often are integral to understanding and modifying behavior in individuals with developmental disabilities. For example, a common treatment for problem behavior maintained by social reinforcement (e.g., attention from others) is the differential reinforcement of alternative behavior (DRA). As part of treatment with DRA, the functional reinforcer for problem behavior is used to shape and maintain appropriate responses. Results of numerous studies indicate that DRA is extremely effective for establishing appropriate behavior and treating inappropriate behavior, especially when problem behavior no longer produces reinforcement (e.g., Carr & Durand, 1985; Day, Horner, & O'Neill, 1994; Shirley, Iwata, Kahng, Mazaleski, & Lerman, 1997).

The efficacy of DRA also likely depends on various parameters of reinforcement for the alternative behavior, such as the schedule, amount, and immediacy of reinforcement. Although few studies have evaluated these factors as part of treatment with DRA, basic findings suggest that these reinforcement parameters may influence free-operant responding in ways that have important implications for the clinical use of differential reinforcement.

Reinforcement may alter several characteristics of the alternative behavior, such as the overall response rate and duration of the postreinforcement pause (PRP). The response may occur infrequently, for example, if reinforcement is too small or too large, too delayed, or too intermittent (Mazur, 1998). Reinforcement variables also may influence the extent to which the alternative response will persist during periods of extinction (i.e., resistance to extinction; Lerman & Iwata, 1996). The appropriate responses of individuals with developmental disabilities may contact extended periods of extinction when caregivers are unable or unwilling to respond to instances of the behavior.

Accordingly, consideration of various reinforcement parameters is important for en-

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suring that adaptive behavior is maintained at high strength in the repertoire of individuals with developmental disabilities. This is especially important within the context of treatment with DRA because problem behavior may reemerge under conditions that are associated with a decrease in the alternative response (e.g., when reinforcement is delayed; Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998). Although the effects of reinforcement schedule and reinforcement delay have been examined in several recent studies (e.g., Fisher, Thompson, Hagopian, Bowman, & Krug, 2000; Hagopian et al., 1998; Hanley, Iwata, & Thompson, 2001; Lerman, Iwata, Shore, & Kahng, 1996), the effects of reinforcement magnitude have received much less attention in the applied literature.

An examination of basic research on the relation between reinforcement magnitude and responding suggests that this factor may be an important determinant of treatment outcome. However, direct application of basic findings on reinforcement magnitude is difficult for several reasons. First, the magnitude of food reinforcers was evaluated in most basic studies, whereas nonfood reinforcers such as attention and escape from instructions are typically delivered in the context of function-based treatments like DRA. Parameters that have been manipulated for food reinforcers (e.g., amount or weight of food, concentration level of sucrose solution) may not be analogous to parameters that could be manipulated for social reinforcers (e.g., duration of access to attention or escape).

Second, basic findings on this factor have been inconsistent. The voluminous literature on reinforcement magnitude and free-operant responding under simple reinforcement schedules has indicated a positive relation, a negative relation, and no relation between magnitude and overall response rates (for reviews, see Belke, 1997, and Bonem & Crossman, 1988). In addition, results of some studies have suggested that smaller magnitudes produce more resistance to extinction than larger magnitudes (e.g., Ellis, 1962; Lamberth & Dyck, 1972; Skjoldager, Pierre, & Mittleman, 1993), whereas other studies have reported the opposite finding (e.g., Barnes & Tombaugh, 1970; Lewis & Duncan, 1957). Factors that influence the nature of these relations have not been thoroughly investigated, but some findings suggest that the reinforcement schedule and the manner in which magnitude is manipulated may interact with the effects of magnitude on responding (e.g., Heyman & Monaghan, 1994; Mellgren, Nation, & Wrather, 1975; Reed, 1991; Wagner, 1961).

In response to these findings, several authors have concluded that a general law of magnitude does not exist (e.g., Collier, Johnson, & Morgan, 1992; Reed, 1991). Furthermore, although magnitude appears to influence responding both prior to and during extinction, these relations likely reflect separate processes (see Nevin, 1992, for a discussion of this issue). It is possible that magnitude could alter resistance to extinction without influencing responding prior to extinction, and vice versa.

Thus, although basic findings suggest that the amount of reinforcement (e.g., duration of praise or escape) that follows occurrences of adaptive behavior might alter response rates or response persistence during treatment with DRA, the clinical significance of this relation is unclear. Although these relations often are described in applied texts and literature reviews (e.g., Kazdin, 2001), few applied studies have examined the effects of magnitude on responding in a single-operant arrangement, and no studies have examined the effects of reinforcement magnitude on resistance to extinction. Preliminary work that bridges basic and applied research on this variable is needed to further our understanding of these complex relations and to identify potential clinical benefits of strategies based on consideration of this factor.

Two experiments were conducted as part of a preliminary evaluation of the relation between reinforcement magnitude and responding during DRA. In the first experiment, the effects of two reinforcement magnitudes on resistance to extinction were examined by reinforcing and extinguishing communication responses after these responses had been acquired as part of treatment with differential reinforcement. The purpose of the second experiment was to evaluate the effects of reinforcement magnitude on various characteristics of responding (i.e., response rates and the PRP) during the maintenance of communication responses.

GENERAL METHOD

Participants and Settings

Timmy was a 4-year-old boy who had been diagnosed with moderate mental retardation and had been referred for the assessment and treatment of disruption (e.g., throwing task materials). He had limited use of the limbs on the left side of his body, an impairment that followed an automobile accident and a subsequent brain operation. Timmy could ambulate independently and had no known sensory deficits. He could speak in sentence fragments and follow simple instructions. Rachel was a 20-year-old woman who had been diagnosed with profound mental retardation and had been referred for the assessment and treatment of self-injury and aggression. She had previously participated in a study on noncontingent reinforcement (Van Camp, Lerman, Kelley, Contrucci, & Vorndran, 2000). Although this treatment was effective, we believed that Rachel also would benefit from communication training. She used a wheelchair and had no known sensory deficits. She had no expressive language skills but could follow simple instructions. Gary was a 10-year-old boy who had been diagnosed with autism and severe mental retardation and had been referred for the assessment and treatment of aggression. Gary took Tegretol® to control seizures and had no known sensory or motor deficits. He had previously participated in a study on the acquisition of functional communication (Kelley, Lerman, & Van Camp, 2002). The maintenance of this communication response was evaluated in the current study. Gary had no expressive language skills but could follow simple instructions. All participants attended self-contained classrooms for individuals with developmental disabilities. Sessions were conducted in unused rooms at the participants' schools. The rooms contained tables, chairs, and other materials necessary to conduct the experiments (see description below).

Response Measurement and Reliability

Touching a communication card (defined as contact between a hand and the card) was selected as the alternative behavior for all participants. Independent card touches were those that occurred without the therapist's assistance (i.e., without verbal, model, or physical prompts). *Disruption* (Timmy) was defined as ejection of a task material more than 0.3 m from its placement on the table. *Aggression* (Rachel and Gary) was defined as hitting, kicking, biting, or pinching any part of the therapist. *Self-injury* (Rachel) was defined as audible contact between the head and hand. Data on the frequency of all target behaviors were collected on laptop computers by trained graduate and undergraduate students, and the data were expressed as number of responses per minute. Prior to calculating the rate of card touches for each session, the total reinforcement time was subtracted from the total session time, and the number of responses was divided by the remaining session time.

Interobserver agreement was assessed by

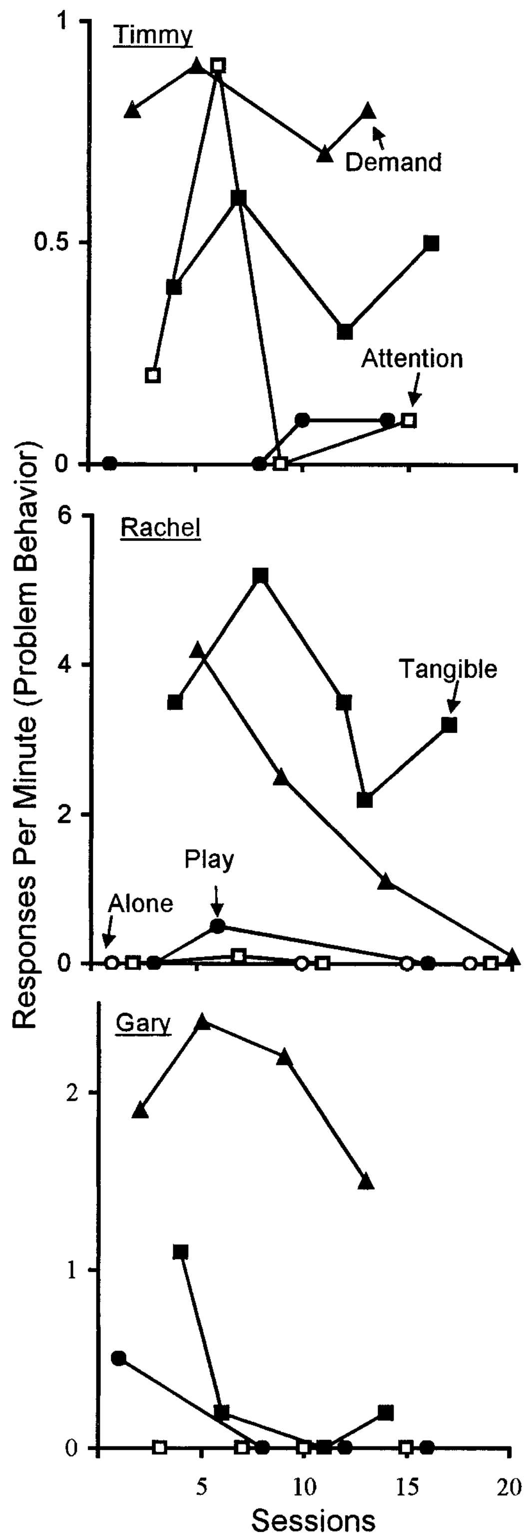

Figure 1. Number of responses per minute of disruption (Timmy), aggression (Rachel and Gary), and self-injury (Rachel) across functional analysis conditions.

having a second observer simultaneously but independently collect data during at least 25% of the sessions during the functional analysis, pretraining baseline, reinforcement, and extinction conditions for each participant. Interobserver agreement for the dependent variables was calculated by dividing each session into consecutive 10-s bins. The number of intervals in which both observers agreed on the number of responses was divided by the number of agreements plus the number of disagreements and multiplied by 100%. Mean exact agreements for independent card touches were 91%, 95%, and 88% for Timmy, Rachel, and Gary, respectively. Mean exact agreements for disruption, aggression, and self-injury were 98%, 99%, and 98.2% for Timmy, Rachel, and Gary, respectively.

Functional Analysis Procedure

Functional analyses were conducted with all participants prior to the study. Procedures were similar to those described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) and included demand, attention, toy play, and tangible conditions, alternated in a multielement design. Participants received 20-s access to the putative reinforcer contingent on problem behavior in all test conditions. Rachel also was exposed to an alone condition to determine if self-injury would persist in the absence of social consequences. The highly preferred items used for the tangible condition were identified via a stimulus preference assessment (e.g., Fisher et al., 1992) conducted for each participant prior to the functional analysis. Two to four 10-min sessions were conducted 3 to 5 days per week, depending on the

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child's schedule. Sessions continued until a clear pattern of responding emerged.

Functional Analysis Results

Results of the functional analyses are shown in Figure 1. For Timmy, the highest rates of disruption occurred in the demand condition (M = 0.8 responses per minute), indicating that his problem behavior was sensitive to escape from instructions. Levels of disruption in the tangible condition (M = 0.5) suggested that access to toys was a reinforcer for Timmy's behavior. Results for Rachel showed that the highest levels of self-injury and aggression occurred during the tangible and demand conditions (M = 3.5 and M = 2.0 responses per minute, respectively). (These data are reproduced from Van Camp et al., 2000.) These findings suggested that Rachel's problem behavior was sensitive to tangible reinforcement (various toys, including a balloon, talking books, and a Koosh® ball). Escape from instructions also may have been a functional reinforcer for Rachel's behavior, but her behavior decreased to zero across the demand condition. Results of Gary's functional analysis showed that rates of aggression were consistently highest in the demand condition (M = 2.0 responses per minute), followed by the tangible condition (M = 0.4). Little or no aggression occurred in the attention (M = 0) and toy play (M = 0.1) conditions. (These data are reproduced from Kelley et al., 2002.) These findings indicated that his aggression was maintained primarily by escape from instructions and that access to tangible items (toys and food) also may have been a reinforcer for Gary's behavior.

Reinforcer Selection

The primary functional reinforcer identified for each participant (i.e., escape from instructions for Timmy and Gary; access to toys for Rachel) was used to establish and maintain the alternative behavior during Experiments 1 and 2. In addition, Gary was taught a second alternative behavior (touching a different communication card) to obtain access to toys and food so that the effects of reinforcement magnitude on his behavior could be reexamined with positive (tangible) reinforcement. Gary first participated in Experiments 1 and 2 with the escape reinforcer; he then participated again in Experiments 1 and 2 with the tangible reinforcer.

EXPERIMENT 1: REINFORCEMENT MAGNITUDE AND RESISTANCE TO EXTINCTION

Procedure

Pretraining baseline. For Timmy and Gary (demand sessions), procedures were identical to those in the demand condition of the functional analysis, except that a communication card was placed on a table within reach of the participant. The therapist delivered continuous instructional trials using a graduated three-step prompting procedure. The instructions involved academic tasks selected by the participant's teacher (sorting objects by color, putting pegs in a board, and stringing beads for Timmy; sorting objects by color and matching numbers and letters for Gary). The therapist provided a 20-s break from instructional trials contingent on each occurrence of disruption (Timmy) or aggression (Gary). During the break, the participant was permitted to leave the table, but attempts to exit the room were blocked by the therapist. No consequences were arranged for the alternative behavior (card touches). For Rachel and Gary (tangible sessions), procedures were identical to those in the tangible condition of the functional analysis, except that a communication card was placed on a table within reach of the participant. The participant had brief access to the tangible items (a balloon, talking book, Koosh® ball, and Big Mac® for Rachel; Koosh® ball, blocks, beads, massager, fruit chews, and soft drinks for Gary) prior to the start of the first daily session. The therapist then removed the items by holding them or placing them on the table out of the participant's reach. The therapist provided 20-s access to the items contingent on each occurrence of the targeted problem behavior, and no consequences were arranged for the communication response.

Initial communication training. The therapist shaped the alternative response using procedures similar to those described by Shirley et al. (1997), and problem behavior was exposed to extinction. Sessions were 10 min long. If the participant did not engage in either problem behavior or the communication response within 5 s after the beginning of the session or the end of each reinforcement interval, the therapist delivered prompts using a graduated, three-step sequence (i.e., verbal, model, and physical prompts). The prompt sequence was then delayed by 1 s for every five consecutive reinforcer deliveries without problem behavior or for every three consecutive trials with independent card touches. The maintaining reinforcer (i.e., 20-s or 60-s access to tangible items or escape from instructions) was provided for each occurrence of the communication response (both prompted and independent). For Timmy and Gary (demand sessions), the therapist immediately guided compliance to the instruction contingent on disruption (Timmy) or aggression (Gary). For Rachel and Gary (tangible sessions), the items were no longer provided for occurrences of self-injury (Rachel) or aggression (both participants). All prompts to touch the card were discontinued when the prompt delay reached 1 min. The reinforcement schedule then was systematically thinned until the terminal variable-interval (VI) schedule was met (VI 45 s for Timmy and VI 60 s for Rachel and Gary). Interval schedules were selected over ratio schedules to decrease the likelihood of ceiling effects in overall response rates. The terminal schedules were similar to those used in basic studies on reinforcement magnitude (e.g., Heyman & Monaghan, 1994; Nevin, 1974; Reed, 1991). Initial training was considered complete after the terminal schedule was reached; then, the response maintenance phase was initiated.

Maintenance (reinforcement). The alternative response continued to be reinforced on the terminal VI schedule, and problem behavior never produced reinforcement. Each session ended when the alternative response had been reinforced five times, and a similar number of reinforcers were delivered across conditions. The communication card was removed during each reinforcement interval. Two different maintenance conditions were conducted with each participant. Under the small-magnitude condition, the reinforcer was delivered for 20 s. Under the large-magnitude condition, the reinforcer was delivered for 60 s. Thus, the duration of access to the reinforcer was three times longer in the large-magnitude condition than in the small-magnitude condition, a difference in magnitude that has been found to influence resistance in basic studies (e.g., Ellis, 1962; Nevin, 1974). The specific values selected (20 s and 60 s) were based on parameters used in previous studies on DRA (e.g., Fisher et al., 2000) and were considered practical for use within the context of ongoing classroom instruction. Maintenance with a given reinforcement magnitude was terminated after at least 55 total reinforcers had been delivered. An attempt was made to hold the number of reinforcers constant across reinforcement conditions for each participant. However, in some cases, the precise number of reinforcers was slightly different across the two conditions when sessions were continued to ascertain that the behavior was being maintained prior to extinction.

Extinction. Neither the alternative behavior nor problem behavior produced access to the reinforcer. For Timmy and Gary (demand sessions), the therapist continued to deliver requests using the three-step prompting procedure and immediately guided compliance contingent on disruption or aggression. For Rachel and Gary (tangible sessions), the therapist removed the items at the start of the session. No programmed consequences were provided for problem behavior or the alternative response. Session length was equal to the average session length during the first reinforcement condition (reversal design) or during both reinforcement conditions (multielement design). Thus, the session length (10 min for Timmy, 9 min for Rachel, 30 min for Gary's demand sessions, and 12 min for Gary's tangible sessions) was identical following the two reinforcement conditions. Extinction continued until the rate of the alternative response remained below 20% of the average rate during maintenance (calculated from the last five sessions) for three consecutive sessions or after 20 sessions, whichever came first.

Experimental Design

A reversal design was used with Timmy, Rachel, and Gary (demand sessions only) to compare the level of resistance to extinction following the two different reinforcement magnitudes. On the basis of laboratory findings (e.g., Barnes & Tombaugh, 1970; Lewis & Duncan, 1957; Nevin, 1974; Wagner, 1961), it was hypothesized that the larger magnitude would be associated with more resistance to extinction than the smaller magnitude. However, results of basic studies indicate that repeated exposure to extinction can decrease resistance (e.g., Clark & Taylor, 1960). Thus, Timmy and Gary were exposed to the small reinforcement magnitude prior to the large magnitude. This strategy ensured that results would not be consistent with our hypothesis simply because the participants' first exposure to extinction followed the large magnitude. To evaluate the possibility of sequence effects, Rachel was exposed to the conditions in the reverse order.

For Gary (tangible sessions only), the reinforcement and extinction conditions were alternated in a multielement design. This strategy was used to further evaluate the possibility that (a) the experimental design (reversal vs. multielement) interacted with the effects of reinforcement magnitude on resistance to extinction (Experiment 1) or on responding prior to extinction (Experiment 2), and (b) reinforcer type (positive vs. negative) interacted with the effects of reinforcement magnitude on responding prior to extinction (Experiment 2). A different therapist and work table were associated with the two different reinforcement conditions. Both the reversal and multielement designs were included because each design has unique strengths and limitations for evaluating extinction effects (see Lerman et al., 1996, for further discussion of this issue). After Gary had met the extinction criterion with both therapists, reinforcement under the two different magnitudes was reinstated to reestablish the response.

Data Analysis

Data on responding during each maintenance (reinforcement) session were expressed as number of responses per minute by subtracting the total reinforcement time from the total session time and dividing the number of responses by the remaining session time. This ensured that response rates under different reinforcement magnitudes were comparable. Data on responding under extinction were analyzed two ways. First, rate of card touches was calculated for each session by dividing the total number of card touches by session time. Second, the response rate in each extinction session was expressed as a proportion of the average response rate under the corresponding reinforcement condition (calculated from the last five sessions) by dividing the response rate by the average rate during reinforcement. The latter measure was included because response rates were not equivalent under the two magnitude conditions for several participants. In these cases, any differences in response rates under extinction following the two reinforcement conditions could have been attributable to differences in the rate of responding under reinforcement rather than to differences in resistance (see Nevin, 1988, for further discussion).

Results and Discussion

Results of the comparison for all participants are shown in Figure 2. Data on problem behavior, which remained low across all maintenance and extinction conditions, and data on the alternative response during the initial training phase (following baseline but prior to the maintenance condition) are not shown, but are available from the first author upon request. Few alternative responses (card touches) occurred prior to training. Following training, card touching was maintained at low to moderate rates for all participants under the terminal VI schedule with either 20-s or 60-s access to the reinforcer. Although overall levels of responding were slightly higher under the 60-s magnitude than under the 20-s magnitude for Timmy (top panel) and Gary (demand sessions only, third panel), this difference could have been due to sequence effects. Both participants were exposed to the small magnitude prior to the large magnitude.

Response patterns during extinction were fairly similar following the two reinforcement magnitude conditions, regardless of whether a reversal or multielement design was used. The number of sessions required to meet the extinction criterion varied across participants (from 11 to 20 sessions) but was fairly consistent across extinction phases for each participant. Similar findings were obtained when the response rate in each extinction session was expressed as a proportion of the average response rate under the corresponding reinforcement condition (data not shown). For example, even though Gary's rate of card touches in the demand context was higher during extinction following the large magnitude (M = 1.0 response per minute) than following the small magnitude (M = 0.4), the levels were similar when expressed as a proportion of reinforcement (M = 1.0 vs. M = 0.8). Thus, the proportion measure was useful for determining that the difference in responding likely was due to differences in the rate of reinforced responding rather than to differences in resistance (Nevin, 1988). An initial increase in responding during extinction (i.e., an extinction burst) was observed only for Gary (demand sessions, third panel). This initial response burst occurred during both extinction phases.

EXPERIMENT 2: MAGNITUDE AND RESPONDING DURING MAINTENANCE

Procedure

Across all conditions, the alternative response continued to be reinforced on the terminal VI schedule, and problem behavior never produced reinforcement. These reinforcement schedules were similar to those used in basic studies on magnitude (e.g., Bradshaw, Ruddle, & Szabadi, 1981; Heyman & Monaghan, 1994; Reed, 1991). Each session ended when the alternative response had been reinforced five times.

Three different maintenance conditions were conducted with each participant. Procedures were identical to those used during the maintenance condition of Experiment 1. In the small-magnitude condition, access to tangible items or escape from demands was delivered for 20 s. In the medium-magni-

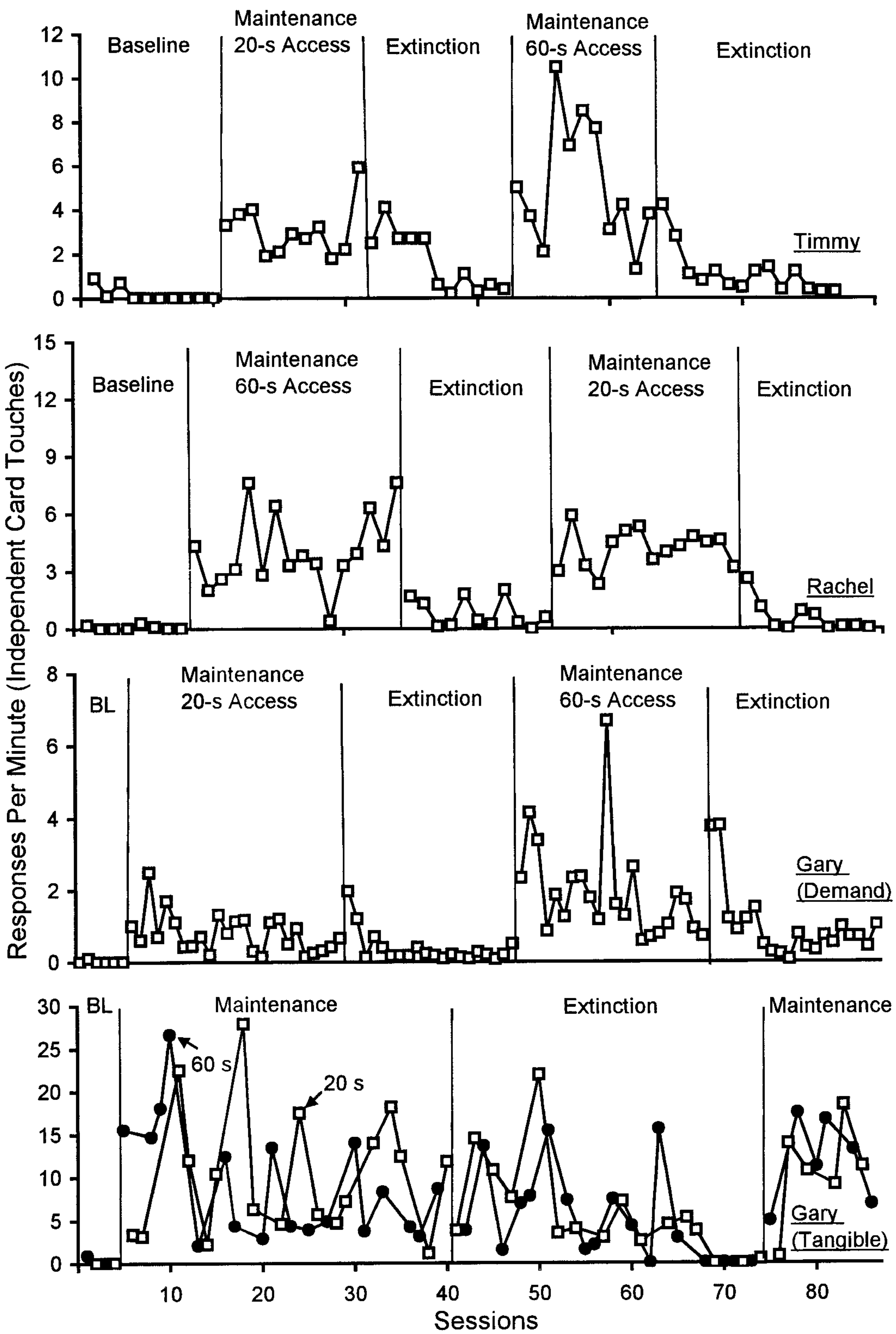


Figure 2. Number of responses per minute of independent card touches across baseline, maintenance (reinforcement), and extinction conditions for Timmy, Rachel, and Gary (demand and tangible sessions).

tude condition, the reinforcer was delivered for 60 s. In the large-magnitude condition, the reinforcer was delivered for 300 s. The latter condition was introduced after responding appeared to be similar under the 20-s and 60-s access conditions in Experiment 1. We hoped to determine if a substantially larger magnitude would alter the characteristics of responding. These values were selected on the basis of laboratory studies in which duration of access to reinforcement was manipulated (e.g., Belke, 1997).

Experimental Design

A reversal design was used with all participants to compare response patterns under the various reinforcement magnitudes. For Gary (tangible sessions only), the small- and large-magnitude conditions also were alternated in a multielement design following the initial evaluation with a reversal design. The multielement design was included because some basic findings indicate that experimental design can interact with the effects of magnitude on responding (e.g., Reed, 1991).

Data Analysis

Data on card touches were analyzed three ways on the basis of previous research in this area. First, overall rates of responding were calculated for each session after subtracting the total reinforcement time from session time. Response rates under the different reinforcement magnitude conditions then were compared. Second, the average duration of the PRP was calculated for each session by determining the latency (in seconds) to the first instance of card touching from the end of each reinforcer-access interval, summing the latencies across reinforcement trials, and dividing by the total number of reinforcers. These durations were then averaged across each reinforcement phase. The median duration value also was determined for each reinforcement phase, because outliers could have substantially influenced the mean duration value in some cases. Third, the average and median running rate, or local response rate, was calculated for each session by subtracting both the total reinforcement time and the total PRP time from the total session time. The number of responses then was divided by the remaining session time, and these rates were averaged across each reinforcement condition. Thus, this calculation generated the average response rate exclusive of both the reinforcement interval and the latency to the first instance of responding, a measure suggested by several authors because magnitude has been found to differentially influence this response dimension (e.g., Belke, 1997; Reed, 1991). The PRP and local response rates for card touches under the 20-s and 60-s maintenance conditions in Experiment 1 also were calculated, and these data were included in the analysis.

Results and Discussion

Overall response rates under each reinforcement magnitude condition are shown in Figures 3 and 4. A reliable difference in overall response rates under the different magnitude conditions was obtained for 1 participant. Rates of card touches for Rachel were higher under the 300-s magnitude condition than under the 20-s magnitude condition (second panel of Figure 3). Levels of responding were relatively similar under the 60-s and 20-s conditions, as observed in Experiment 1. For Timmy and Gary (demand and tangible sessions in the reversal design), an initial increase (Gary) or decrease (Timmy) in responding was associated with at least one transition from the 300-s condition to the 20-s condition, but overall response rates remained relatively similar across phases (first and third panels of Figure 3; top panel of Figure 4). The differences in response rates under the 20-s and 60-s mag-

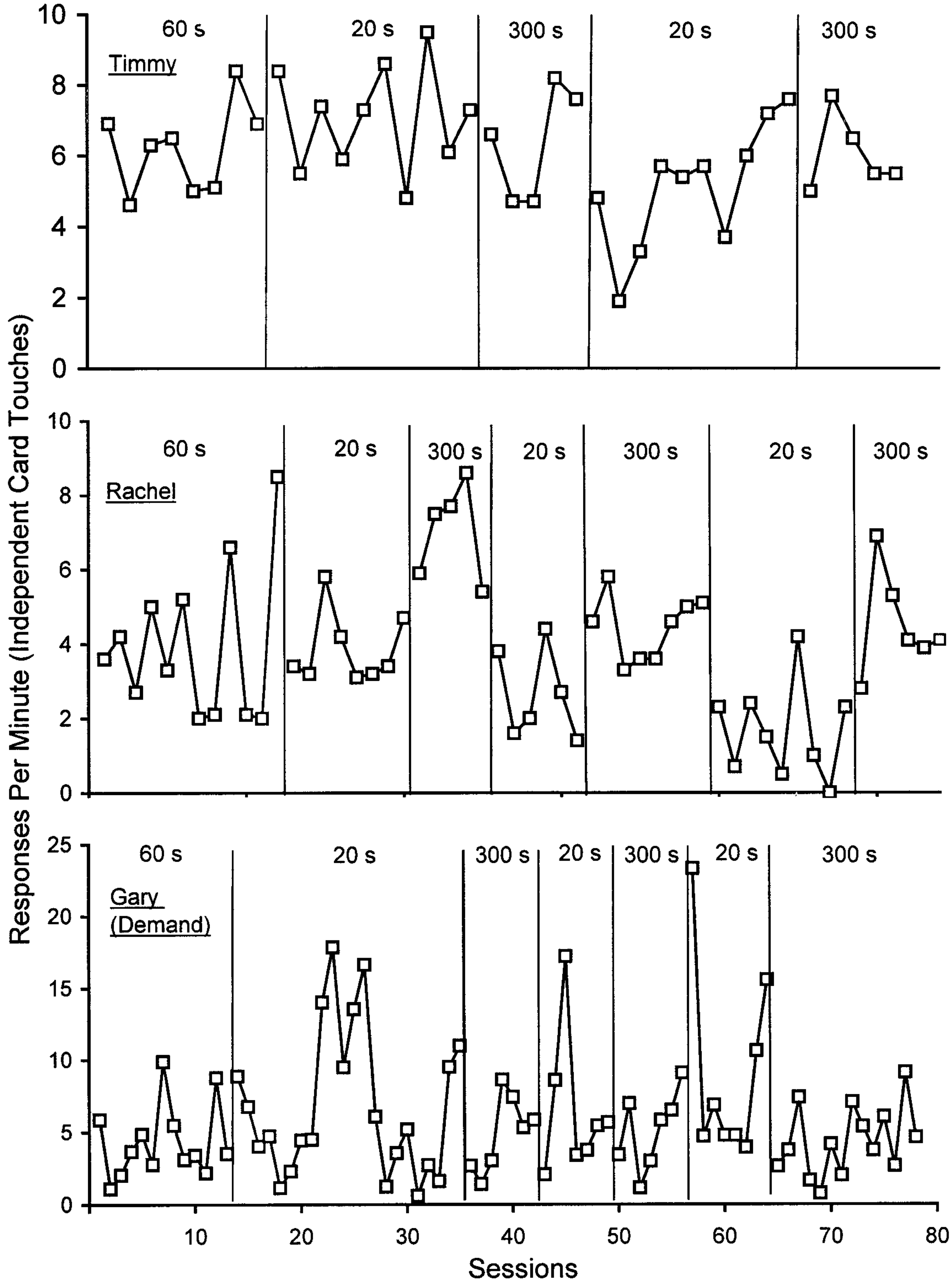
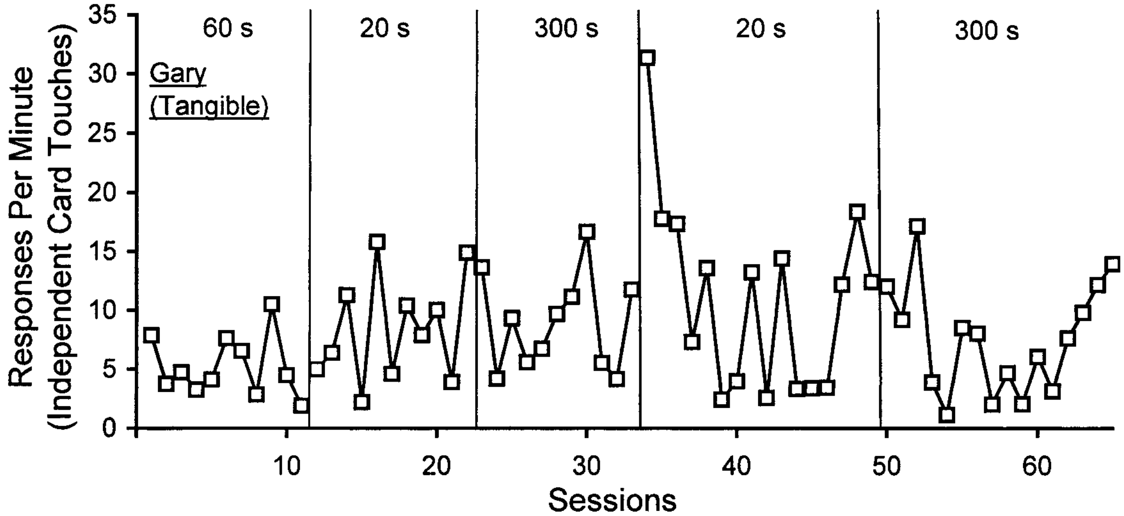


Figure 3. Number of responses per minute of independent card touches under 20-s, 60-s, and 300-s magnitude conditions for Timmy, Rachel, and Gary (demand sessions).



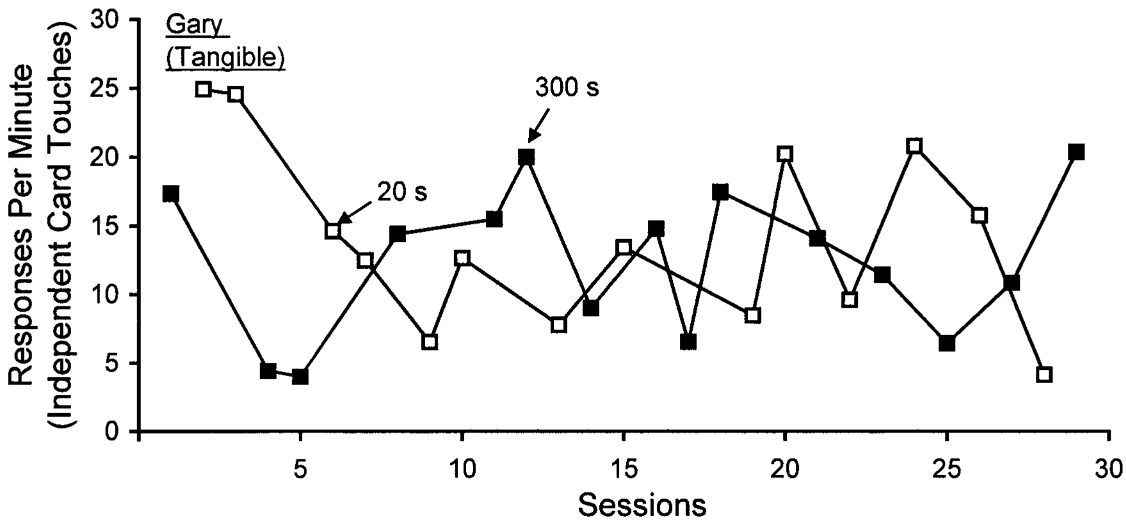


Figure 4. Number of responses per minute of independent card touches for Gary (tangible sessions) under 20-s, 60-s, and 300-s magnitude conditions alternated in a reversal design and under 20-s and 300-s magnitude conditions alternated in a multielement design.

nitude conditions observed in Experiment 1 were not replicated during the first two phases of Experiment 2. Thus, the initial differences likely were due to sequence effects. Response rates appeared to be somewhat more variable under the 20-s magnitude than under either the 60-s or 300-s magnitudes for Gary (demand sessions only). Response rates were similar under the 20-s and 300-s conditions when a multiele-

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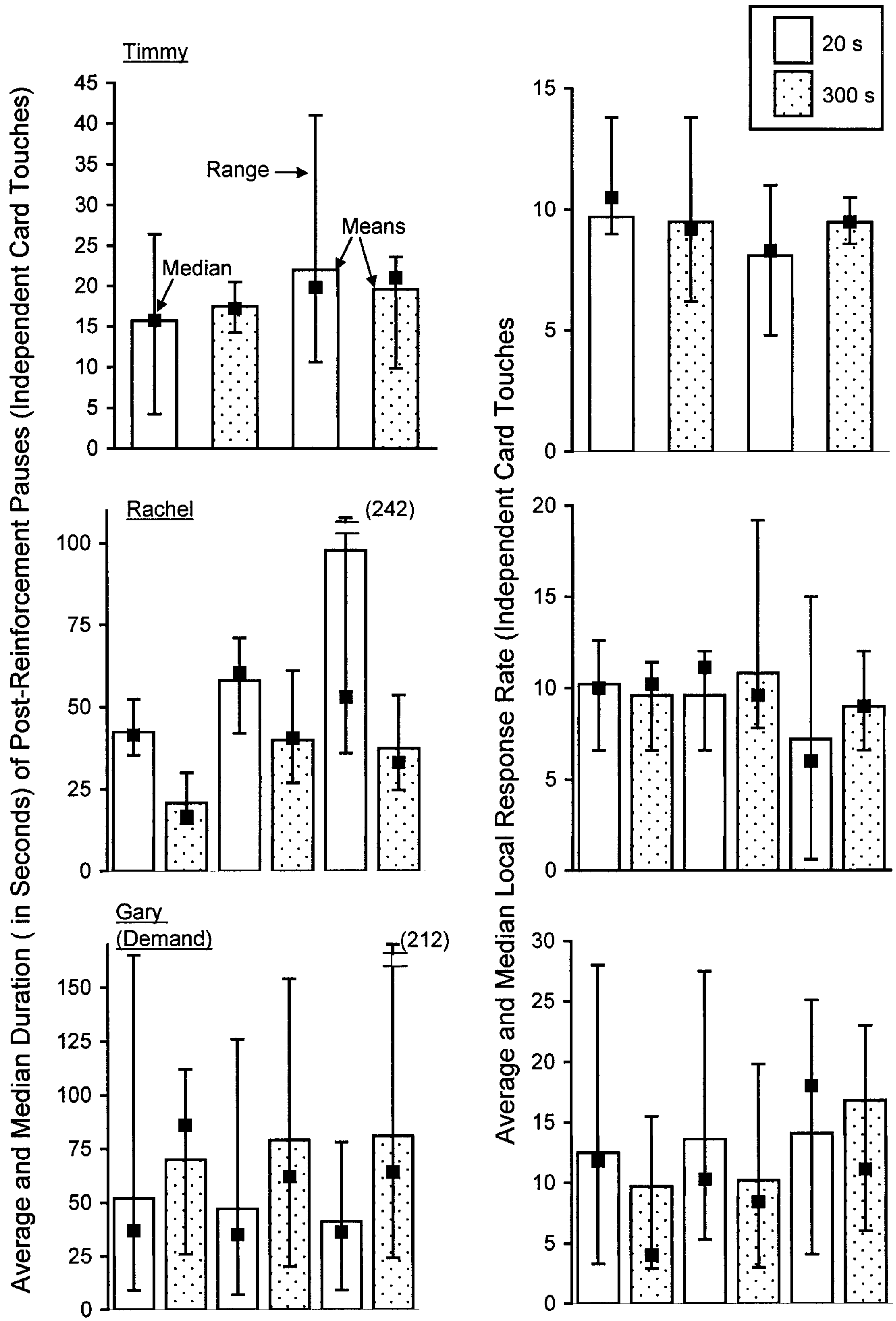
Figure 5. Average and median duration (in seconds) of the postreinforcement pause for independent card touches across 20-s and 300-s conditions for Timmy, Rachel, and Gary (demand sessions); average and median local response rate for independent card touches across 20-s and 300-s conditions for Timmy, Rachel, and Gary (demand sessions).


20 s
300 s
Timmy
Range
Means
Median
Rachel
(242)
Gary
(Demand)
(212)
Average and Median Duration (in Seconds) of Post-Reinforcement Pauses (Independent Card Touches)
Average and Median Local Response Rate (Independent Card Touches)

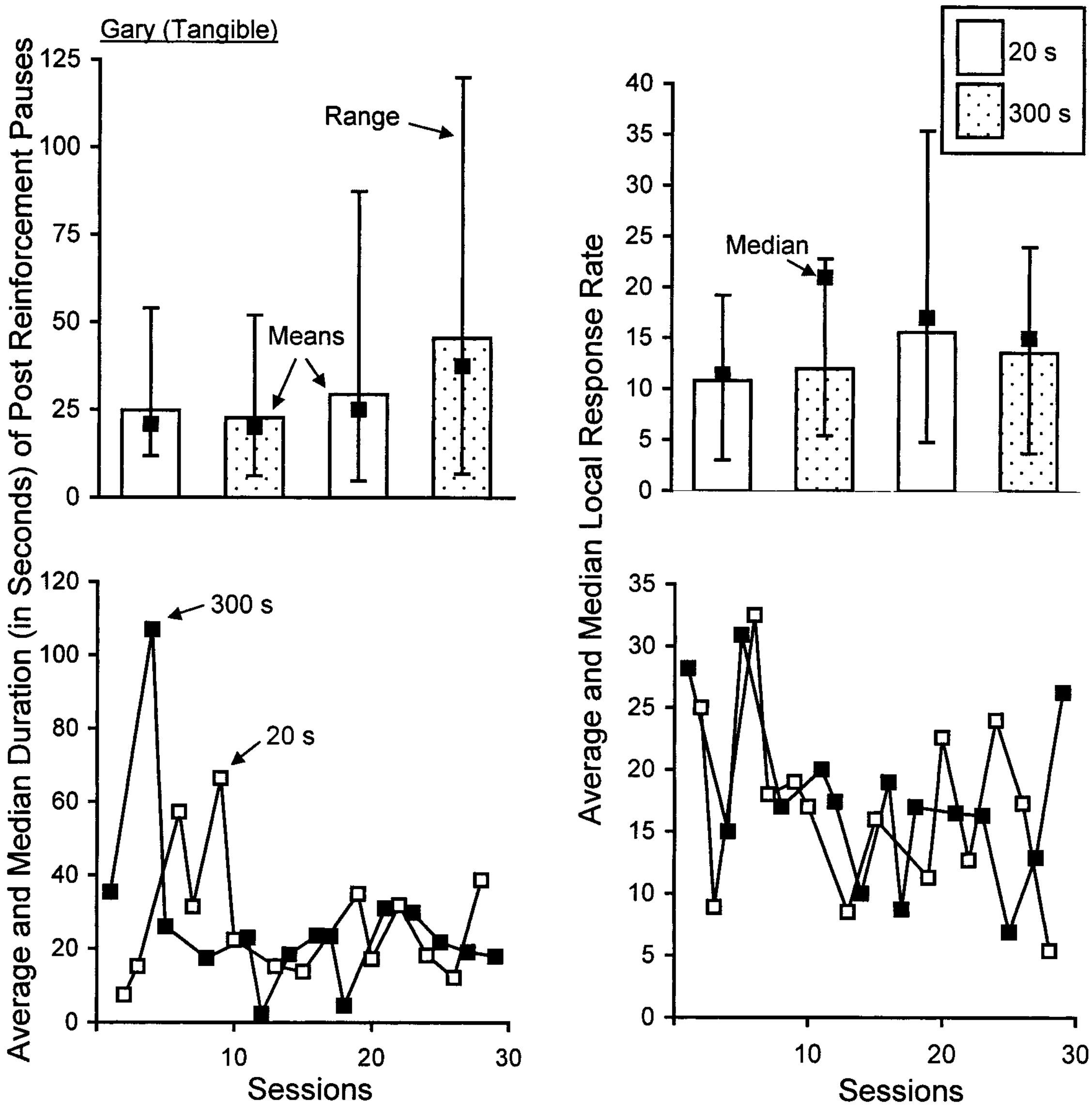


Figure 6. Average and median duration (in seconds) of the postreinforcement pause for independent card touches across 20-s and 300-s conditions for Gary (tangible sessions alternated in a reversal [top left panel] or multielement [bottom left panel] design); average and median local response rate for independent card touches across 20-s and 300-s conditions for Gary (tangible sessions alternated in a reversal [top right panel] or multielement [bottom right panel] design).

ment design was used with Gary (tangible sessions, bottom panel of Figure 4).

Average duration of the PRP (with ranges and medians) and average local response rate (with ranges and medians) under the 20-s and 300-s reinforcement phases are displayed in Figures 5 and 6. Session-by-session data on these measures are displayed for Gary when the two reinforcement magnitudes were alternated in a multielement design (tangible sessions). Results of the analyses for the 60-s condition in Experiments 1 and 2 are not shown because no differences were found. For 2 participants, outcomes suggested that the average and median duration values of the PRP were different under the 20-s condition than under the 300-s condition. Results indicated a negative relation between the duration of the pause and reinforcement magnitude for Rachel (second left panel of Figure 5) and a positive relation between the pause and magnitude for Gary (demand sessions only, third left panel of Figure 5). The ranges for the PRP were fairly broad, and it is clear that the durations overlapped across reinforcement conditions. However, the median values suggested that outliers were not solely responsible for the overall differences in the average pause. With the exception of Gary (demand sessions only), no consistent differences in the average or median local response rates were obtained across reinforcement conditions (right panel of Figure 5). This finding indicates that, for Rachel, the effect of magnitude on the PRP was solely responsible for the difference in overall response rates under the 20-s and 300-s conditions. Results for Gary suggested that the local response rate was negatively related to reinforcement magnitude (right bottom panel of Figure 5). However, this result should be interpreted cautiously due to the variability in the data.

Although it was hypothesized that the type of reinforcer—positive (tangible items) versus negative (escape)—might interact with these relations, the PRP and local response rates were similar across reinforcement conditions for Gary when the experiment was conducted with tangible reinforcers (top and bottom panels of Figure 6).

GENERAL DISCUSSION

Preliminary findings on the relation between reinforcement magnitude and responding during DRA indicated that this variable may only minimally influence resistance to extinction or overall response rates within the context of a single-operant arrangement. With the exception of the PRP, the characteristics of appropriate behavior exposed to different durations of social reinforcement (access to tangible items or escape from instructions) were fairly similar prior to and during extinction. These primarily negative findings should be useful for guiding further research on reinforcement magnitude (e.g., by identifying the conditions under which potent functional relations would not be expected to occur) and, more generally, for guiding clinical applications of differential reinforcement (e.g., by identifying a broad range of durations that are likely to produce similar outcomes during maintenance). Furthermore, results suggest that descriptions of these relations may need to be qualified in applied textbooks and literature reviews (e.g., Kazdin, 2001).

On the basis of laboratory findings, we hypothesized that behavior exposed to the larger reinforcement magnitude would be more resistant to extinction than behavior exposed to the smaller magnitude in Experiment 1 (e.g., Barnes & Tombaugh, 1970; Lewis & Duncan, 1957; Mellgren et al., 1975; Wagner, 1961). It is possible that basic findings in this area are not directly applicable to adaptive behavior maintained by social reinforcers. On the other hand, a variety of parameters (e.g., experimental design, reinforcement duration, type and density of the reinforcement schedule, length of exposure to each reinforcement condition) may interact with the effects of reinforcement magnitude.

For example, a greater difference in the duration of social reinforcement (e.g., 1-s vs. 300-s access) or thinner reinforcement schedules (e.g., VI 2 min) may have been necessary to show a relation between magnitude and resistance. Alternatively, confounding features of the experimental designs may have obscured the differential effect of reinforcement magnitude on resistance. Within-subject designs are not ideal for evaluating resistance to extinction. Prior exposure to reinforcement and extinction may influence responding under subsequent conditions when resistance is evaluated via a reversal design, and interaction effects may confound the results when reinforcement and extinction conditions are alternated within multielement or multiple baseline designs. These potential confounding features might be minimized in future studies by comparing the effects of different reinforcement magnitudes across topographically dissimilar responses.

Finally, magnitude may fail to influence resistance if behavior is not under discriminative control of the different conditions prior to extinction. This possibility could be evaluated in future studies by arranging stimulus conditions in a concurrent-operants format under which two responses differentially produce access to small versus large reinforcement magnitudes. Response allocation prior to extinction could be examined to evaluate the discriminative properties of the conditions.

Predictions about the relation between reinforcement magnitude and the characteristics of responding under reinforcement were somewhat more difficult to extract from the basic literature. However, we hypothesized that overall or local response rates would decrease and that the PRP would increase under the larger reinforcement magnitude in Experiment 2. One or both of these findings have been obtained with various types of reinforcers (food pellets, sucrose solution, access to wheel running) in studies using simple VI schedules and free-operant responses (e.g., Belke, 1997; Lowe, Davey, & Harzem, 1974; Reed, 1991). Results for Gary during the demand sessions were consistent with this hypothesis. Although the duration of the PRP was quite variable, the pauses tended to be lengthier under the 300-s condition than under the 20-s condition. Local response rates also tended to be lower under the 300-s condition, although this finding was less clear or consistent than that obtained for the PRP.

Results for Rachel, however, also were consistent with those reported in some basic studies on reinforcement magnitude. That is, a positive relation between overall response rates and reinforcement magnitude (as determined by the volume or sucrose concentration of liquid) was obtained in several studies using simple VI schedules and free-operant responses (Bradshaw et al., 1981; Bradshaw, Szabadi, & Bevan, 1978; Heyman & Monaghan, 1994). However, the PRP was not examined in these studies. Results for Rachel indicated that overall rates were higher under the 300-s magnitude than under the smaller magnitudes because her pauses following the 300-s reinforcement intervals tended to be shorter, not because she responded more quickly during the VI interval. Basic studies also have shown that reinforcement magnitude can have a greater effect on the PRP than on other response dimensions (e.g., Lowe et al., 1974). Nevertheless, ceiling effects may have prevented an increase in Rachel's local response rates when the 20-s condition was switched to the 300-s condition. Results of the few applied studies on reinforcement magnitude and free-operant responding also failed to show a relation between this parameter and response rate (Ecott, Foate, Taylor, & Critchfield, 1999; Lerman, Kelley, Van Camp, & Roane, 1999).

The effects of magnitude on the PRP are difficult to explain because a positive relation (Gary, demand sessions), a negative relation (Rachel), and no relation (Timmy; Gary, tangible sessions) were obtained. Reinforcement magnitude typically has produced inconsistent effects across participants in basic studies, leading some authors to suggest that this reinforcement parameter may not be a fundamental determinant of behavior (Reed, 1991). It is possible, however, that the large reinforcement magnitude decreased Gary's motivation to engage in escape behavior because the rate of demands was necessarily lower under the 300-s condition than under the 20-s and 60-s conditions (e.g., Smith, Iwata, Goh, & Shore, 1995). For Rachel, 300-s access to toys may have functioned as a higher quality reinforcer than 20-s or 60-s access, increasing her motivation to respond for the toys. Presumably, a positive relation between the PRP and reinforcement magnitude would have been obtained for Rachel if even lengthier access to the toys produced within-session satiation. The effects of a particular magnitude value may be idiosyncratic even when the relation between responding and magnitude is consistent across individuals.

Various explanations for the effects of magnitude on response rates have been proposed in the basic literature (see Reed, 1991, for a review). For example, some authors have suggested that an increase in response strength under larger reinforcement magnitudes (e.g., Herrnstein, 1970) or the presence of factors that produce contrast effects (e.g., Reynolds, 1961) are responsible for the positive relation between magnitude and response rate. Reed suggested that larger magnitudes more effectively strengthen the response patterns maintained under a given reinforcement schedule. Thus, reinforcement magnitude will be negatively related to overall response rates under schedules that produce low levels of responding (e.g., differential reinforcement of low response rates, VI) and positively related to overall response rates under schedules that produce high levels of responding (e.g., variable ratio). None of these theories, however, can adequately account for all of the findings reported in this study or in the basic literature.

The most clinically relevant finding of this investigation was that a relatively short reinforcer (20 s) generally maintained appropriate behavior as well as much lengthier reinforcers (60 s, 300 s). Obviously, using short but effective reinforcers allows more time for teaching and learning than equally effective longer reinforcers. Clinicians may wish to begin a reinforcement program with relatively short reinforcement intervals and then lengthen them only if responding is not maintained at the desired level.

The preliminary results of Experiment 2 suggest that further research on reinforcement magnitude is warranted. Although the clinical significance of the effects obtained for Rachel and Gary is uncertain, the relation between magnitude and the PRP has some practical implications for the use of reinforcement in the natural environment. For example, lengthier PRPs for requests to break from academic situations may result in more exposure to learning trials (i.e., less frequent breaks) and less disruption to the flow of instruction. Shorter PRPs for requests for tangible items may be beneficial if frequent access to stimuli is important for preventing occurrences of severe disruptive behavior or for promoting skills related to tangible reinforcers (e.g., appropriate toy play). When frequent requests for tangible reinforcers would interfere with academic activities, magnitudes that produce lengthier PRPs probably would be preferable. In Rachel's case, the 20-s access time was recommended for use in the classroom because (a) problem behavior remained low across all magnitude conditions, (b) the smaller magnitude was adequate to maintain a steady rate of requests, and (c) a larger proportion of her instructional time was devoted to academic and self-care skills than to play skills.

Thus, further research is needed on conditions that produce a reliable relation between reinforcement magnitude and responding with clinical populations and functionally relevant reinforcers. The parameters selected for this study constituted a reasonable starting place, and the results should be useful for guiding additional studies. Pertinent factors that should be considered include the type of reinforcement schedule (e.g., interval vs. ratio; single vs. concurrent), dimension of magnitude (e.g., duration of access vs. number of items), level of magnitude, type of reinforcer (e.g., positive vs. negative; primary vs. generalized), and experimental design.

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STUDY QUESTIONS

1. What were the results of the functional analyses, and how were they relevant to the design of the intervention procedures?

2. What contingencies were in effect during the DRA maintenance conditions of Experiments 1 and 2?

3. What were the main differences in experimental conditions across Experiments 1 and 2?

4. Describe the two ways in which data on responding during extinction were analyzed in Experiment 1 and the type of information afforded by each.

5. How were the data in Experiment 2 analyzed, and why were different measures used?

6. Briefly summarize the main results obtained during extinction in Experiment 1 and during maintenance in Experiment 2.

7. What explanations did the authors provide for the finding that reinforcer magnitude seemed to exert little influence over behavior in this study?

8. What was the most clinically relevant finding, and why?

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